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AN AUTOMATIC DIALING DEVICE
FOR USE WITH A
DESK TYPE DIAL TELEPHONE

A THESIS

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the Faculty of the Graduate Division

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SUMMARY

This study is concerned with the design and construction of an automatic dialing device for use with a desk dial telephone. The operation of the device is in no way to interfere with the normal operation of the telephone system. A punched paper tape memory is used to store numbers frequently called and a ten-button keyboard is used to dial other numbers. Placing a call to a number in the memory is accomplished without having to hold the telephone receiver during the operation. If the called telephone number is busy or not answered, the dialer will automatically hang up, wait a specified length of time and initiate the dialing procedure again.

The solution to the problem entailed the design of suitable relay circuits that would accept one digit at a time from the punched paper tape memory and would transfer the digit to the dial drive motor. After the digit has been dialed, the relay circuits were required to reverse the drive motor and step the memory tape to the next digit. A transistor amplifier was also required that would detect the presence of a dial tone, ringing tone or busy tone and operate a relay each time the pulse is detected. A means of automatically redialing an unanswered number was also needed. This required the design of an additional relay circuit and timing system.

The dialer consists of two units: the major unit contains the power supply, memory system, keyboard, relay switching circuitry, transistor amplifier and the redialing reset and timing circuit. The other unit is

mounted on the dial face of the desk subscriber set. In this unit is housed the motor and mechanism for rotating the telephone dial, a cradle for holding the telephone receiver, a solenoid for operating the cradle button and an induction coil for detecting the various tones.

The results of this study indicate that an automatic dialing device with an automatic redialing feature can be designed that will not interfere with the normal operation of the telephone system. The system resulting from this study provides a practical method of performing this function.

CHAPTER I

INTRODUCTION

Purpose of Development.--Some recent advances in science and technology result from an effort to lessen the number of routine or repetitive operations a business man must perform every day and thus to release him to do more creative tasks. One such area of advancement has been in the telecommunications field.

The introduction of Direct Distance Dialing has greatly reduced the time required to complete a call to a distant city. This system has reduced the time required to place a long distance call to approximately that required for a local call. In the field of telecommunications by far the majority of telephone calls are local, and frequently such calls are made to a business phone already in use. In these cases the time required to dial the number and wait for the busy tone to be returned is wasted and the operation must be repeated later. When a busy number is called, the person placing the call must interrupt whatever he is doing (thus disrupting his train of thought) to perform the routine dialing operation, only to receive a busy tone and to find it necessary to repeat the operation later. For this reason a device is needed that will automatically perform this function and relieve the calling party of such interruptions.

Statement of Problem.--The problem is to design and construct a compact automatic dialing device. The device is to be used in conjunction with

any existing subscriber desk set. The operation of the unit is in no way to interfere with the normal operation of the telephone system. A punched paper tape memory will be used to store frequently called numbers. A ten-button keyboard will also be included for the dialing of all other numbers. Placing a call to a number in the memory is to be accomplished without the necessity of lifting the telephone receiver and holding it during the operation. When the called telephone is answered, the calling party is to be notified by an audible signal. If the called line is busy or not answered, the dialer is to contain an automatic redialing procedure that will be automatically initiated. The redialing procedure will consist of disconnecting the telephone, waiting a specified length of time and automatically dialing the number again.

CHAPTER II

REVIEW OF THE LITERATURE

In the literature on the subject, four similar systems were found that deal with this problem to some extent.

Automatic Dialing Device for Dial Telephones (1) (2).--In 1954 Lee de Forest patented an Automatic Dialing Device for Dial Telephones. This unit is mounted on the side of the subscriber desk set and has a hinged driving mechanism that drops down on the dial face. The memory consists of punched cards that must be removed from the storage to the operating position. The caller must hold the receiver during the operation. The dialing device has no method of automatically redialing.

Transistorized Repertory Dialer (3).--The repertory dialer was developed by the Bell Laboratories. The apparatus has a memory capacity of 50 thirteen-digit numbers and can be used both for local and direct-distance dialing. The memory numbers are pre-set by "notching" codes on circular discs. In initiating a call the caller locates the desired name in an indicator, picks up the receiver of his telephone, listens for the dial tone, and then depresses the start button. The dialer is directly connected to the existing telephone equipment at the wall mounted terminal box. This unit has no redialing feature.

Drum-operated Automatic Dialer (4).--Vinod Sundra, a student at the Massachusetts Institute of Technology, designed the drum-operated dialer.

The memory unit is a rotating drum, five inches in diameter and seven inches long. It has a capacity of twenty-five numbers. The system, like the Repertory Dialer, directly connects to the wall mounted terminal box. A redial procedure is contained in the dialing apparatus. The redial feature is, however, an instantaneous redialing procedure which repeats itself continuously without a waiting period.

Dialaphone (5) (6) (7) (8).--The fourth type of dialer is produced by the James Kilburg Corp. The Dialaphone employs a perforated tape memory and is capable of storing 500 to 850 numbers. Early models had a dialing arm mechanism that dropped down on the telephone dial face. Later models, however, do not have this mechanism. The Dialaphone is electrically connected to the telephone set. There is no automatic redialing feature.

CHAPTER III

GENERAL OPERATION AND COMPONENT DESCRIPTIONS

The entire system consists of two components as shown in Figure 1. The main component as shown in Figure 2 consists of a memory system, keyboard, relay switching circuits, transistor amplifier and the reset and timing circuit. The second component is shown mounted on the dial face of a desk type subscriber set. This unit as shown in Figure 3 contains the motor and mechanism for operating the telephone dial, a cradle for holding the telephone receiver, a solenoid for operating the cradle button, and a means of detecting the various tones.

Placing a call to a number in the permanent memory is accomplished without having to lift the receiver and hold it during the operation. To initiate a call, the caller places the proper name in the indicator window by turning the knob on the side of the main housing. The caller then places the "Auto Dial" switch on. The unit dials the called party automatically. When the called telephone rings, the calling party is notified by an audible signal. The person placing the call can now do either of two things.

He can lift the receiver and hold it until the party answers. The operation of lifting the receiver disconnects the dialing system. If the called telephone is not answered, then the caller must replace the receiver in its cradle. Under these conditions the redial procedure will not be initiated.

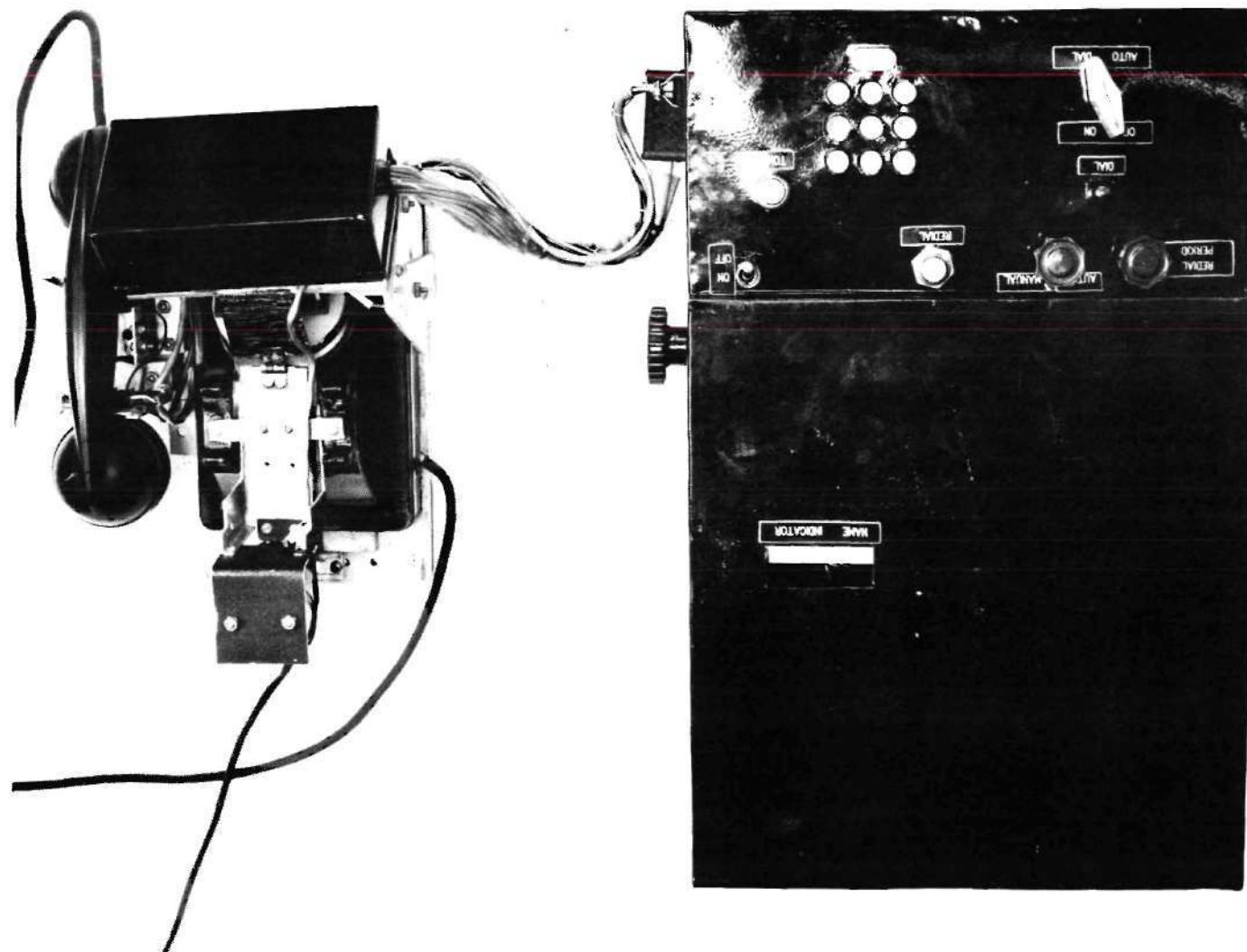


Figure 1. Automatic Dialing Device.

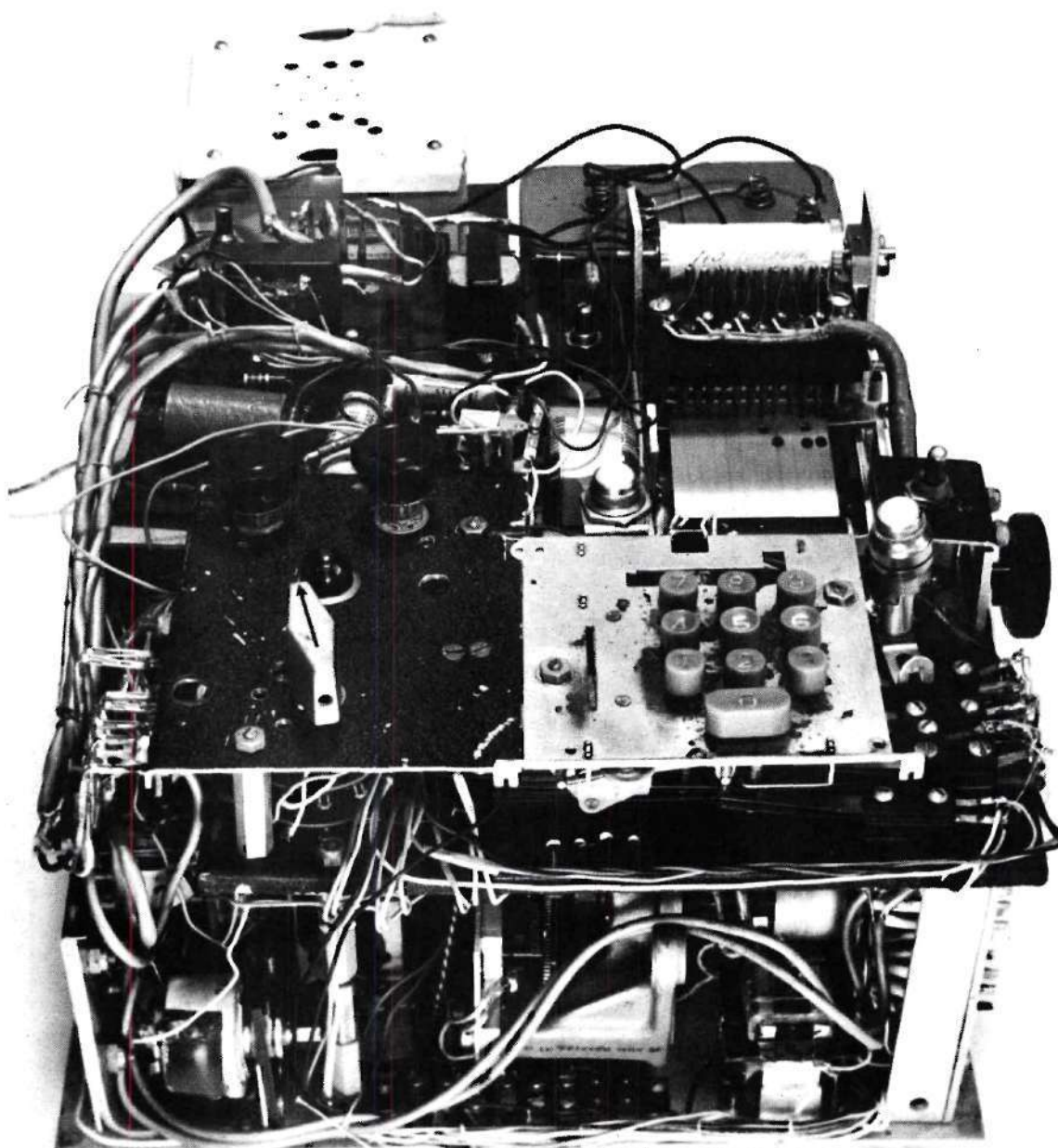


Figure 2. Main Component of Dialing Device.

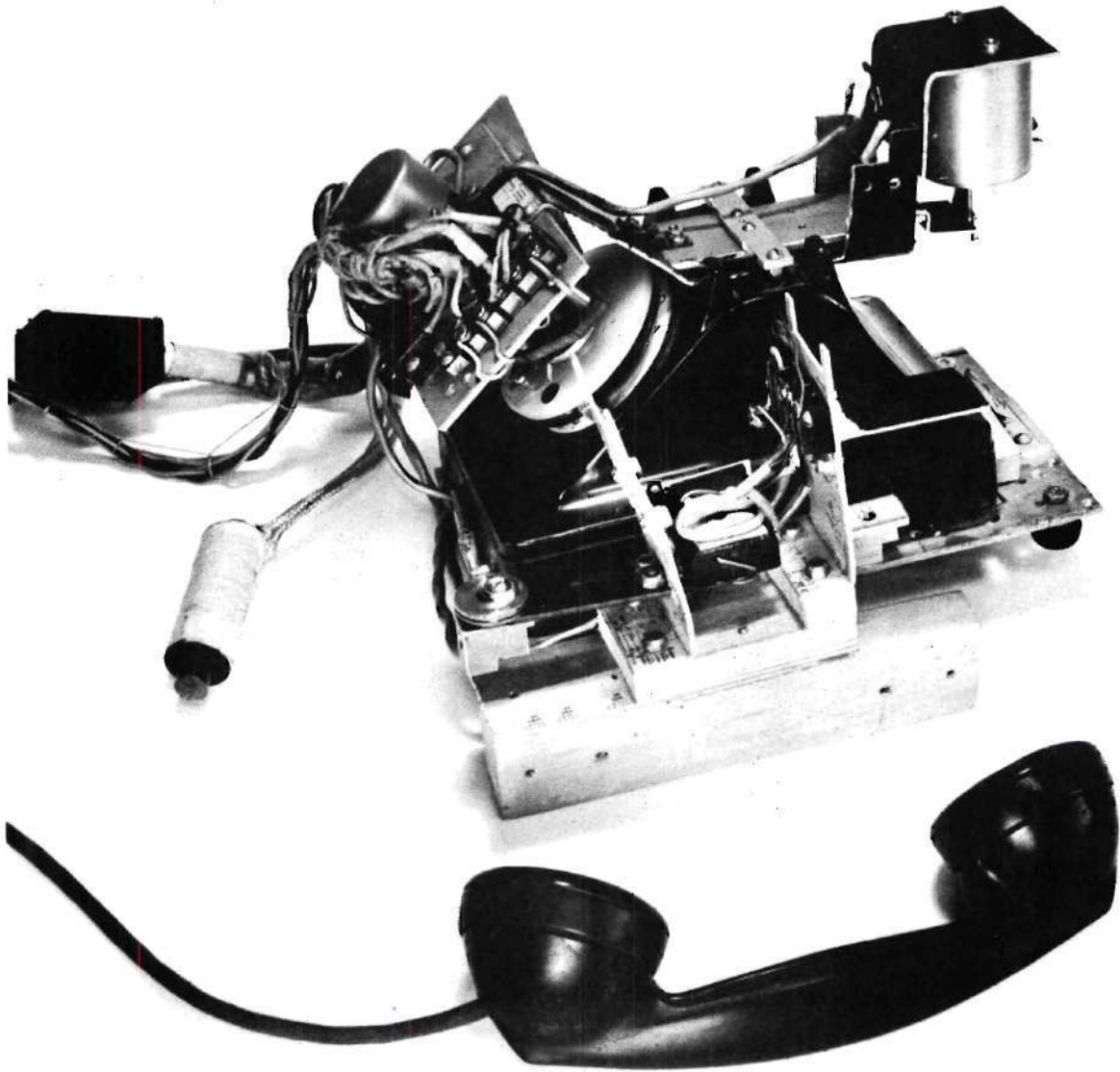


Figure 3. Minor Component Mounted on Subscriber Set.

The alternate choice is to leave the receiver in its cradle. In this situation the desired number is rung five times. If the called telephone is answered the answerer's voice is heard by means of the speaker. This notifies the caller to lift the receiver. If the called telephone is not answered before the fifth ring, the dialer automatically hangs up and the redialing procedure is initiated. The dialing unit waits a specified length of time and then initiates the dialing operation again. This sequence of operations is repeated until either the call is completed or the person placing the call discontinues the operation. The waiting period in the redial operation is employed to allow for incoming calls. The Redial lamp glows during the waiting period. When an incoming call is answered, the redialing procedure is discontinued.

The pushbutton keyboard is used for dialing numbers not stored in the permanent memory. The Auto-Manual switch is set to "Manual." The caller now places the Dial switch on.

Each time a digit is keyed, the Dial lamp goes out. One key at a time is depressed and held until the Dial lamp glows again. The glowing of the lamp indicates that the dialer is prepared to receive the next digit. After the number has been dialed, the same procedure as used for a memory stored number is followed except for the redial procedure.

Memory.--Frequently called numbers are stored in the memory by means of a punched paper tape. The present tape is capable of storing seven telephone numbers but this number could easily be increased. This tape is mounted in the dialer so as to form a continuous tape loop. The tape is 2-1/4 inches wide and is provided with eleven punched columns. Each

telephone number stored on the tape consists of eight digit rows of one or two punchings each with the exception of row one. The actual telephone number is stored on digit rows one through seven. Row 9 and also row 1 are used for indexing. An example of the telephone number 876-9521 is shown in Figure 4. The last punched column, column X, is used for indexing purposes in the redialing operation. The ten punched columns correspond to the digits 1 to 10. These columns are used for storing the actual telephone number. The tenth or "0" column serves a dual purpose. Digit rows 1 through 7 of each telephone number in addition to having a hole punched for a particular digit of the number also have a hole in the tenth column. This tenth column punching performs two functions. First, the punching is used to key the dialing mechanism for each digit at the proper time. Second, if the proper digit is not read from the tape the dialer will not jam the telephone dial against the finger stop, but will simply dial the digit zero. This operation will result in a misdial but will protect the subscriber set from possible damage. The hole in the first digit row, column X, is used to properly index the telephone number at the end of the redial waiting period. The column X hole in the ninth row energizes the pick-up coil under the subscriber set. This enables the dialer to detect the busy tone or ringing tone.

A register relay capable of being stepped in either direction is used to step the tape one digit row at a time. Ten steps in either direction completes one revolution of the register. The register is operated on 50 volt a. c.

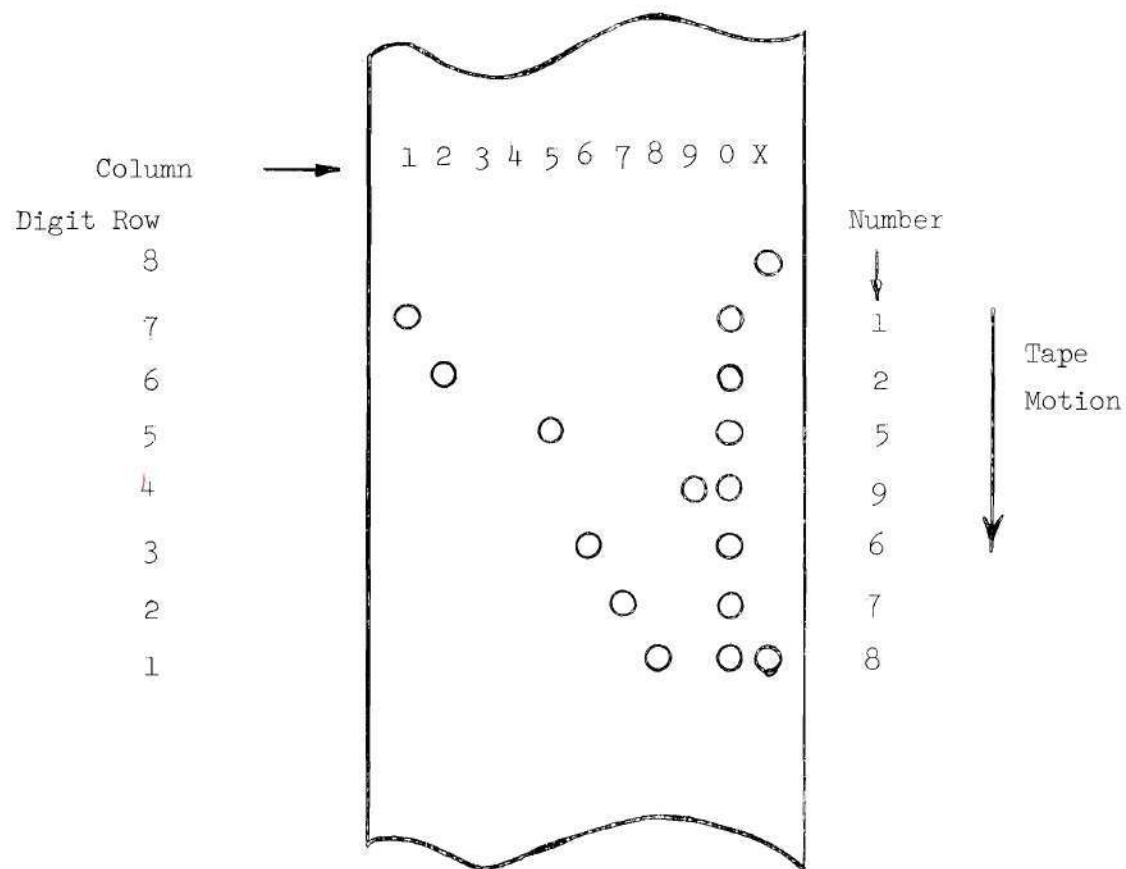


Figure 4. Tape Memory of 876-9521

The reading mechanism consists of an aluminum bar and eleven spring loaded metal fingers. The tape is fed between the bar and the fingers. To the bar is applied 27 volts d. c. As each digit row of the tape is fed under the reading fingers the proper finger makes contact with the metal bar through the punched holes. In the tip of each finger a tiny ball is mounted that reduces the wear on the tape that would result from sliding contacts.

Dialing System.--The mechanical dialing mechanism is mounted on the dial face of the subscriber set as shown in Figure 3. A 27 volt d. c. permanent-magnet motor is mounted perpendicular to the telephone dial face. To the shaft is mounted a plexiglass disk with a metal finger. This metal finger fits in the zero finger hole of the telephone dial. Corresponding to the tape reading fingers 1 through 10 there are ten properly spaced contacts mounted around the motor shaft. Voltage is applied to each of these contacts 1 through 9 when the corresponding reading finger makes contact with the aluminum bar of the reader. To wiper contact 10 is constantly applied a voltage. These contacts are wiped by a wiper mounted on the plexiglass disk as the motor rotates the telephone dial. When the wiper touches a contact to which voltage is applied the motor is reversed and the dial unwinds. A single pole double throw switchette is operated each time the dial returns to its rest position. The relay circuits employed in the dialing system are contained in the main housing. All of the relays are operated on 27 volt d. c.

The dialing circuit is shown in Figure 5 and is explained in detail in Appendix II.

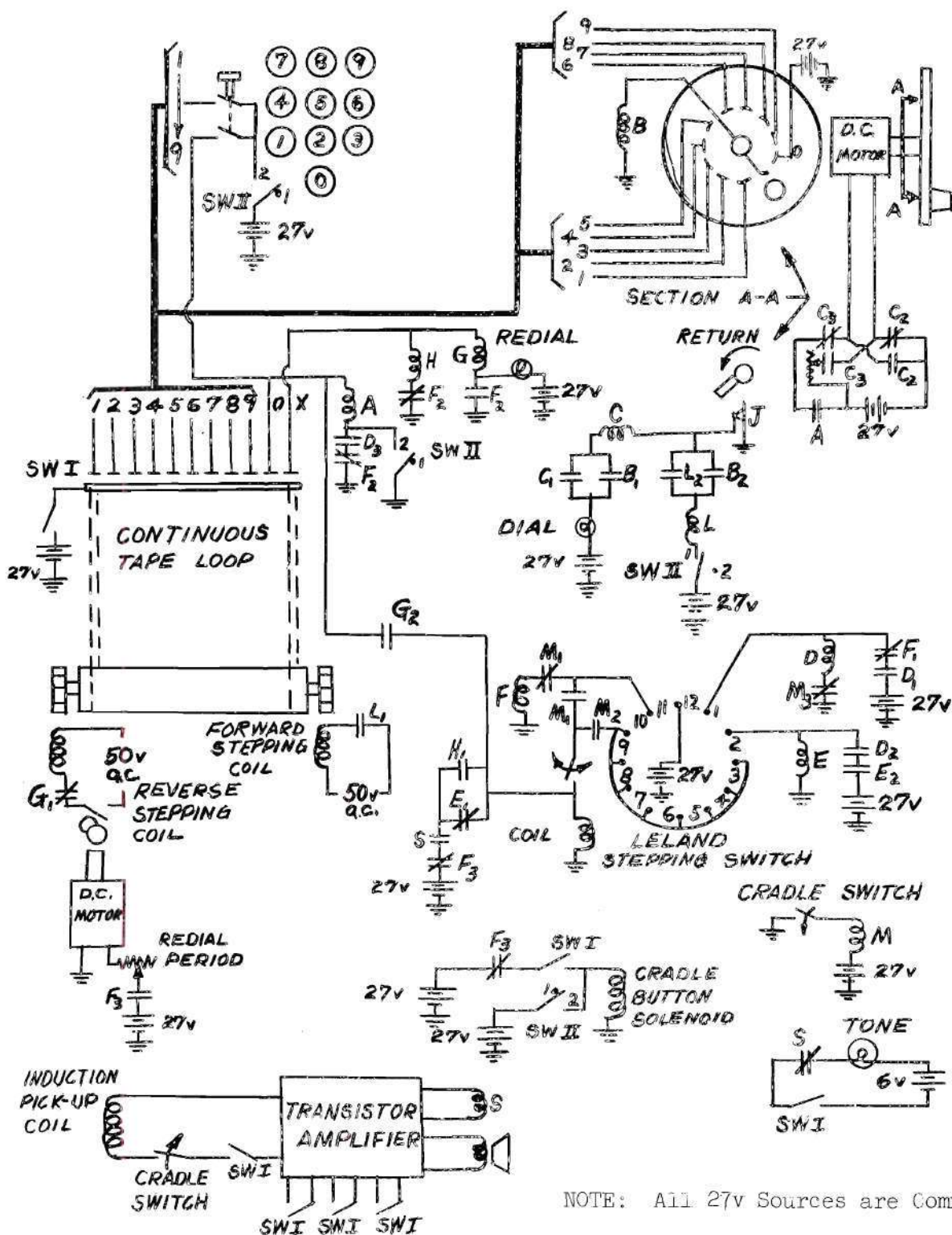


Figure 5. Automatic Dialing Device Circuit Diagram

Tone Detection.--An induction pick-up coil is mounted under the base of the subscriber set. The coil consist of 3500 turns of 30HF wire on 1/2 inch diameter iron core.

The pick-up coil is connected to the input of a transistor audio amplifier using three 2N107 transistors. The output of this amplifier is connected to two transistor amplifiers which operates a sensitive relay. A detailed circuit diagram of the amplifiers is included in Appendix I. Portions of the amplifier circuit were taken from the amplifier used in the POP'tronics Secretary (9) and the loudspeaker audio amplifier shown in the General Electric Transistor Manual (10).

Across the output of the first amplifier is also connected a 4 inch speaker to provide an audible indication when the ringing tone is received. The tone detector operates on the presence of a tone pulse.

Redialing System.--The redialing system is shown in Figure 5.

The detection of the dial tone operates the sensitive relay. This operation steps the Leland stepping switch one position. The stepping switch in this first position completes the circuit to the dial drive motor and the dialing procedure begins. The detection of any additional tone or noise on the line steps the Leland switch to the second position. In this position, the tone detection circuit is broken until the number has been dialed. When the last digit of the stored number has been dialed, the tape is stepped one more time to digit row 8. As mentioned earlier, the eighth digit row contains a punching in column X. Thus the stepping of the tape to the eighth digit row serves to reconnect the tone detection system. Each interruption of the busy or dial tone will operate

the stepping switch. Nine tone interruptions will move the switch to its eleventh position. When the switch reaches the eleventh position the telephone is hung up by the operation of the cradle solenoid. In addition the timing and reset procedures are begun. The timing motor is energized and the Redial lamp lights. Each revolution of the timing motor operates a switchette. The closure of the switchette steps the tape back one digit row at a time. When the first digit row moves under the reading fingers the reset procedure is completed. The contact of the eleventh reading finger through the column X punching moves the stepping switch to the twelfth position and the dialing procedure is initiated again.

CHAPTER IV

CONCLUSIONS AND RECOMMENDATIONS

An automatic dialing device with an automatic redial feature can be designed that will not interfere with the normal operation of the telephone system. The automatic dialer requires no direct electrical connection to the telephone company lines. The device is capable of dialing telephone numbers stored on a punched paper tape memory. If the called telephone is busy or is not answered the dialing device can automatically hang up the telephone, wait a specified length of time and initiate the dialing procedure again.

The experience gained in the course of this development has indicated that certain design modifications would improve the system performance. Another means of stepping the tape memory needs to be devised to reduce the excessive noise. A possible solution would be employing a small d. c. motor and turning it on and off through another column of punchings in the tape. A silent stepping switch is desired to replace the Leland stepping switch used. A silent means of releasing the cradle button must be employed.

Additional features could be added to provide more versatility. Possibly using the transistor amplifier in the dialer the system could be converted to hands-free operation. In such a hands-free operation it would not be necessary to lift the receiver to conduct the conversation. The person using the dialer would simply begin talking and his voice

would be picked up by a microphone and transmitted to transmitter of the telephone receiver.

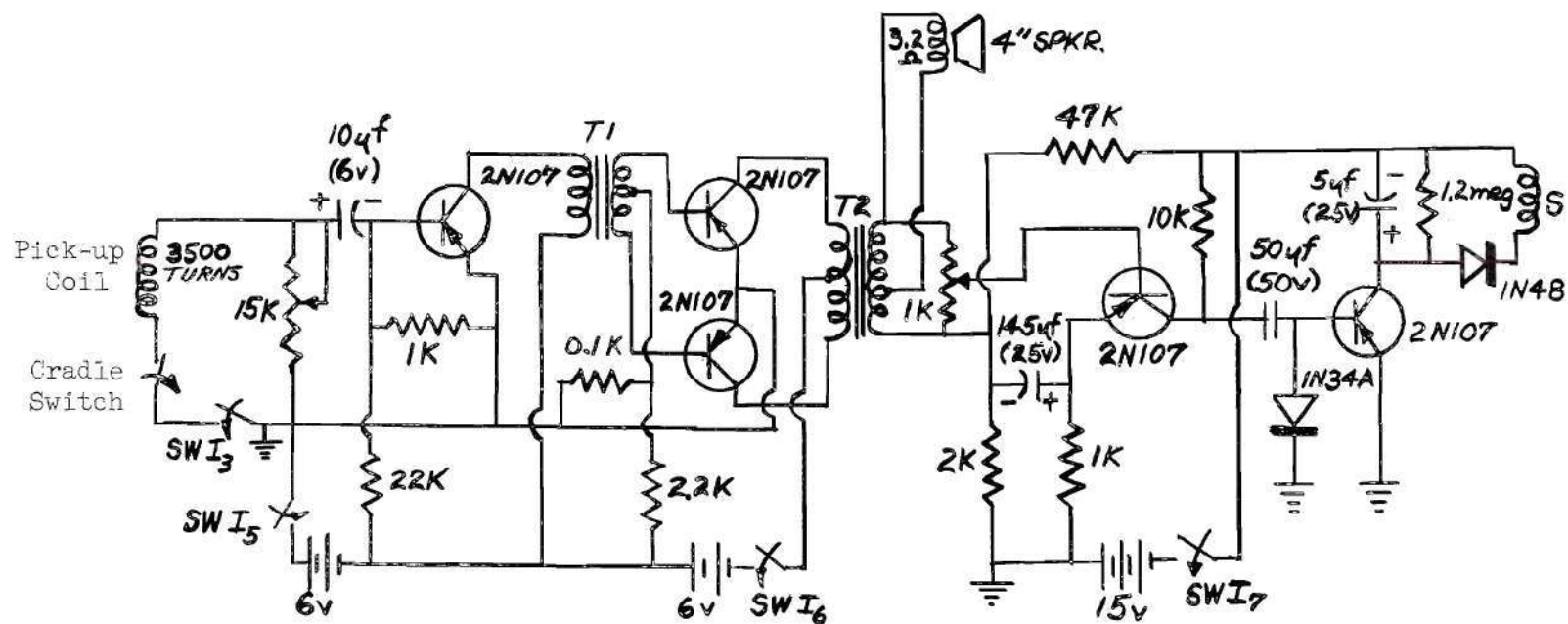
Another additional feature would be an automatic answering system (9). This system would provide means for the telephone to be answered and messages recorded by a tape recorder when no one is present to answer the telephone.

By enlarging the dialing device a temporary memory consisting of an additional stepping switch and ten additional relays could be added. This memory would temporarily store a number punched on the keyboard and would provide the redialing procedure for such numbers.

Through the use of miniature components the main parts of the system could be greatly reduced in size and weight.

APPENDIX I

TONE DETECTION AMPLIFIER



S = Sigma Relay 11F-1000-G-SIL
 T₁ = Triad A-81X or equivalent
 T₂ = Triad S-51X or equivalent
 All resistors .5 watt

Figure 6. Tone Detection Amplifier Circuit Diagram

APPENDIX II

STEP-BY-STEP SYSTEM OPERATION

Automatic dialing of a number in memory.--For the purpose of illustration the following operation is described for the dialing of the number 876-9521. The punched tape for this number appears in Figure 4. The operations, as outlined below, refer to Figures 5, 6 and 7. The calling party must perform the first five operations. Then the dialer automatically begins the actual dialing operation.

1. Locate the desired person's name in the NAME INDICATOR by turning the knob on the right side of the main unit. This places the tape memory of the person's number in the proper position with the first digit row under the tape reading fingers.

2. Set the REDIAL PERIOD for the time desired. This switch establishes the length of the waiting period between redialing operations and can be varied from $3/4$ minute to $1-1/2$ minutes.

3. Place the MANUAL-AUTO switch (SW II) in the AUTO position. This operation effects the following:

- a. The voltage is removed from the keyboard.
- b. Positive 27 volts d. c. is removed from one side of the cradle solenoid and applied to one side of relay L.
- c. Direct ground is removed from one side of relay A.

4. Place the AUTO DIAL switch (SWI) in the ON position. This operation effects the following:

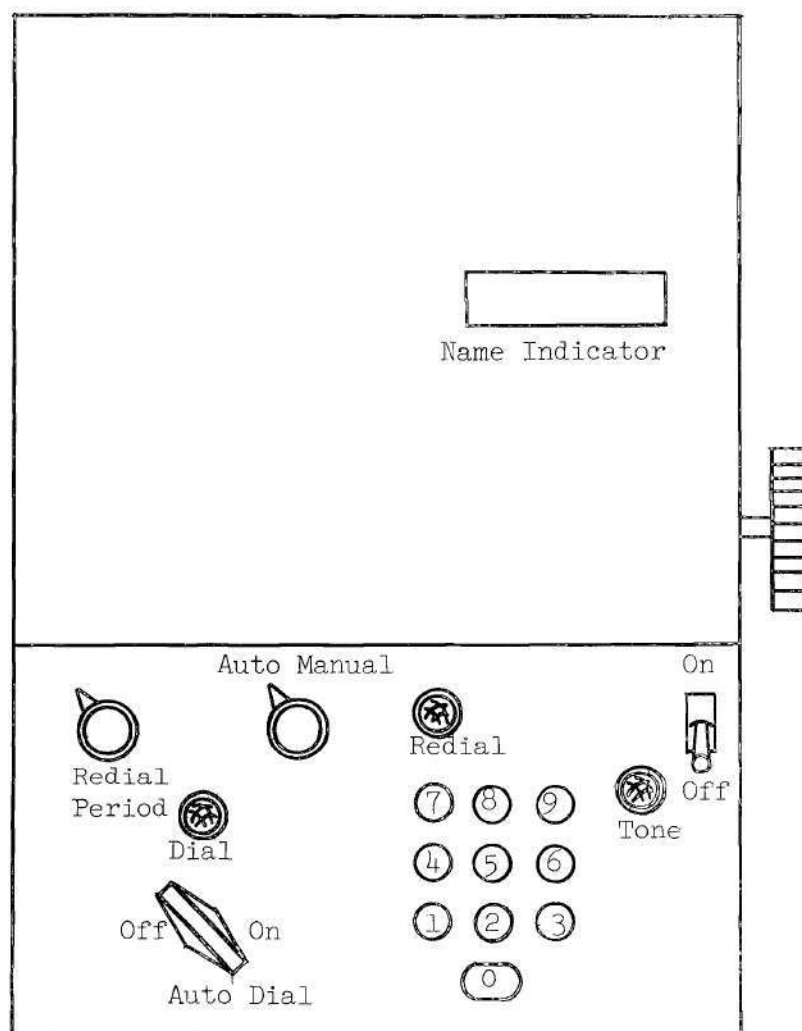


Figure 7. Layout of Dialing Device Controls.

- a. Positive 27 volts d. c. is applied to the metal reading bar located under the reading fingers.
- b. The circuit is completed to the cradle solenoid and it operates releasing the receiver cradle button.
- c. The input circuit to the tone detection amplifier is completed.
- d. Within the amplifier the batteries are applied to the circuit.
- e. The circuit is completed to apply 6 volts d. c. to the TONE lamp. Turning on the tone detection amplifiers momentarily operates the S relay. When the TONE lamp lights the S relay has been released and step 5 may be performed.

5. Place the ON-OFF switch in the ON position. This operation applies the necessary voltages to the system. With the dialing mechanism not energized, contact J is open and all other relays are not operated.

The following operations are performed automatically.

6. The presence of the dial tone is detected by the tone detection amplifier and relay S is operated. To the Leland stepping switch is applied 27 volts d. c.

7. The stepping switch is stepped to position 1.

8. Relay D is operated and holds in through the D_1 contacts.

a. Ground is applied to relay A.

b. The hold-in circuit for relay E is partially completed.

Any noise or additional pulse on the telephone line operates relay S a second time. This operation causes the Leland stepping switch to step to position 2. Relay E is operated and locks in through contact E_2 and contact

D₂. Contact E₁ is opened and opens the circuit to Leland stepping switch coil.

9. A voltage is applied through the 0 punching in the tape to finger 0 and the 8 punching in the tape to finger 8.

- a. The 0 finger energizes relay A which in turn completes the dial drive motor circuit through the normally closed contacts of relay C.
- b. The voltage through finger 8 is applied to the eighth wiper contact located around the drive shaft on the dial face.

10. The motor having been energized begins to rotate the telephone dial. When the motor moves from its rest position contact J is opened. This places ground on one side of relay C and prepares the circuit to relay L.

11. When the wiper on the dial drive shaft wipes the eighth contact the circuit is completed to relay B.

12. Relay B operates.

- a. Voltage through the DIAL Lamp is applied to relay C through the B contact.
- b. The circuit to relay L is completed.

13. Relay C operates.

- a. Contact C₁ locks in the applied voltage to relay C so that the relay will not release when relay B is released.
- b. The polarity of the voltage applied to the dial drive motor reverses and the motor rotates in the reverse direction.

14. Relay L operates.

- a. The applied voltage is locked in through the L₂ contact.

- b. The circuit to the forward stepping coil at the tape loop is completed through the L_1 contact and the tape is moved one position placing the second digit row of the desired number under the reading fingers.

15. When the wiper on the drive shaft moves off of the eighth contact relay B is released.

16. The dial drive shaft is returned to its rest position by the motor running in the reverse direction. The speed of the motor in the reverse direction is adjusted so that the telephone dial is free of the driving mechanism and returns at its normal rate. Contact J is operated when the drive shaft reaches its rest position.

17. The opening of contact J releases relay C. The polarity on the drive motor is reversed through the contacts of relay C.

18. The circuit to relay L is opened and the forward tape stepping coil is released.

19. The movement of the tape opens the circuit to relay A.

- a. Relay A releases and the voltage to the drive motor is removed.

The operation cycle starting with step 9 above now repeats itself except this time voltage is applied through the 0 and 7 punchings.

When the digit zero is desired, only the 0 is punched in the tape. In this situation, the drive motor rotates until the wiper wipes the zero contact. The constantly applied voltage to this contact operates relay B. This constant voltage serves as a safety feature in the event that if no voltage is applied to one of the earlier wipers due to a malfunction then the drive motor will automatically reverse when the wiper reaches

contact 0. In such a situation the drive motor is prevented from attempting to rotate the dial beyond its stop point.

The operation cycle, steps 9 through 19, is repeated for the seven digits of the desired telephone number. When the seventh digit is dialed in step 19 above the tape is stepped to the eighth digit row of the stored number.

19. b. Voltage is applied through the "X" punching in the tape.

20. Relay H operates through the normally closed F_2 contact. The input circuit to the Leland stepping switch is completed through the H_1 contact.

21. Either the busy tone or ringing tone is detected by the amplifier. Relay S operates with each pulse of either tone. In the event that a busy tone is received the procedure below is followed.

22. a. The Leland stepping switch steps one position each time relay S operates.

b. When the Leland stepping switch reaches position 11 relay F operates.

(1) Relay D is released by the opening of contact F_1 . The releasing of relay D releases relay E.

(2) Ground is removed from relay H and relay A by the opening of contact F_2 and applied to relay G and the REDIAL Lamp. The REDIAL Lamp glows.

(3) The circuit to the cradle solenoid is opened by contact F_3 . The receiver cradle button is depressed by the solenoid and the telephone calling circuit is broken.

(4) Through make contact F_3 voltage is applied to the timing motor.

- c. Each revolution of the timing motor operates a switchette.
- d. Each closing of the switchette applies voltage to the reverse tape stepping coil.
- e. The tape is stepped backward one digit row at a time.
- f. When the tape is stepped back to the first digit row, voltage is applied through the "X" punching to the "X" reading finger.
- g. The voltage on the X finger operates relay G through contact F_2 . Voltage is applied to the Leland stepping switch through the 0 punching and contact G_2 and the switch steps to position 12.
- h. Relay F is released.
 - (1) Ground is applied to relays H and A through the normally closed contact F_2 .
 - (2) Ground is removed from REDIAL lamp.
 - (3) The cradle solenoid circuit is completed and it operates releasing the receiver cradle button.
 - (4) The timing motor is stopped.

The dialing operation automatically begins again with the detection of the dial tone in Step 6.

If a ringing tone is received instead of a busy tone then the following procedure is followed.

- 23. a. The Leland stepping switch steps one-position each time relay S operates and the ringing tone is heard through the small speaker.

- b. The caller has the choice of either lifting the receiver and holding it to his ear until the other party answers or leaving the receiver in the dialer cradle, waiting until the answerer's voice is heard through the small speaker and then lifting the receiver. If the receiver is not lifted and the ringing tone continues, relay S will operate on each pulse.
- c. (1) Corresponding to each operation of relay S the Leland stepping switch will step one position. If the called telephone is not answered the Leland switch will continue to step to its position 11.
(2) When the stepping switch reaches position 11 relay F operates. The same redial procedure as outlined above for the busy tone starting with step 22b will be followed.

If the calling person lifts the receiver from the dialer cradle the 2 PDT dialer cradle switch will close.

- d. (1) The closing of contact 1 of the cradle switch operates relay M.
 - (a) The Leland stepping switch will automatically step itself to position 12 through the M_2 make contact.
 - (b) Relay D is released by the opening of contact M_2 . The releasing of relay D opens the circuit to the forward tape stepping coil and releases relay E.

- (2) Opening of contact 2 of the cradle switch opens the input circuit to the tone detection amplifier.

The conversation proceeds as usual and after the conversation the DIAL switch and the ON-OFF switch are returned to their OFF positions.

Manually dialing of a number by means of pushbuttons.--The manual dialing operation outlined below is for the telephone number, 876-9521 and refers to Figures 5 and 7.

1. Place the MANUAL-AUTO switch (SW II) in the MANUAL position.
 - a. The circuit is completed to apply voltage to the keyboard when the dialer is turned on.
 - b. The circuit to relay L is disconnected and the circuit from the cradle solenoid directly to positive 27 volts
 - d. c. is completed.
 - c. Direct ground is applied to one side of relay A.
2. Place the AUTO DIAL switch (SW I) in the OFF position. In this operation voltage is not applied to the metal bar under the tape reading, fingers, to the transistor amplifier, and the input circuit to the amplifier is not completed.
3. Place the ON-OFF switch in the ON position. The cradle solenoid operates.
4. Lift the receiver from the dialer cradle and wait for the dial tone.
5. Depress and hold in the 8 key on the keyboard.
 - a. Relay A operates and completes the circuit to the dial drive motor.

- b. Positive 27 volts d. c. is applied through the 8 key to wiper contact 8 located around the drive motor shaft on the dial face.

6. The dial drive motor begins to rotate the telephone dial. When the motor moves from its rest position contact J is closed. The ground circuit is completed to relay C.

7. When the wiper on the dial drive shaft wipes the eighth contact the circuit to relay B is completed.

8. Relay B operates. Voltage is applied to relay C through the B contact.

9. Relay C operates.

- a. Contact C_1 locks in the applied voltage to relay C to hold it in when relay B is released.
- b. The polarity of the dial drive motor voltage is reversed and the motor rotates in the reverse direction.
- c. The DIAL lamp lights.

10. When the DIAL lamp lights the 8 key can be released and the 7 key depressed and held. If the 8 key is not released the dial drive motor will return to its rest position and dial the number 8 again. If the 8 key is released and another key is not depressed and held the dial drive motor will return to its rest position and stop.

11. When the wiper on the drive shaft moves off of the eighth contact relay B releases.

12. The dial drive motor returns to its rest position. Contact J is opened.

13. Relay C releases. This operation removes the polarity of the dial drive motor.

14. If the 7 key of the desired telephone number is depressed relay A is operated.

- a. The voltage circuit to the drive motor is completed through the contact of relay A.
- b. Positive 27 volts d. c. as applied through the 7 key to wiper contact 7.

15. The above operation starting with step 6 repeats itself. This procedure is continued until all seven digits are dialed.

The calling party listens for the ringing or busy tones and proceeds as usual. The ON-OFF switch is returned to the OFF position at the end of the conversation.

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